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WIND REGIME PECULIARITIES IN THE LOWER THERMOSPHERE IN THE WINTER OF 1983/84

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This report analyses temporal variations of prevailing winds at 90-100 km obtained from measurements carried out in winter 1983/1984 at three sites of the USSR (Obninsk, Volgograd and Khabarovsk) and two sites in the German Democratic Republic (Kuhlungsborn and Collm). These variations are compared with those of the thermal stratospheric regime.

Measurements in Obninsk, Khabarovsk and Kuhlungsborn were carried out using the drifts D2 method (meteor wind radar) and in Collm by the Dl method (ionospheric drifts). In Obninsk and Khabarovsk wind data were obtained simultaneously in for directions and in Volgograd measurements were carried out using the Greenhow method.

Temporal variations of zonal and meridional prevailing wind components for all of the five sites are given in Figures la, lc,. Fig. la presents also zonal wind data obtained using the partial reflection wind radar in Saskatoon (Canada) (NAUJOKAT and LABITZKE, 1984). Wind velocity values (Fig. la) for Saskatoon were obtained by averaging data recorded at this site between 105 and 91 km altitude. Wind velocity data averaged in such a way can be related to about the same height interval to which the data obtained by the meteor radar and ionospheric methods at the other considered sites refer, i.e., to the mean height of the meteor zone (about 95 km).

Firstly, it is worth noting the good agreement between the temporal course of zonal and meridional prevailing wind components measured in the opposite directions (S-N, W-E) for Obninsk and Khabarovsk. This indicates that the spatial scales of synoptic wind field inhomogeneities in the lower thermoshere exceed significantly the distances between the opposite sounding regions which are spaced some 300-400 km apart.

The results presented in Fig. la and lc show that there are significant fluctuations about the seasonal course of both zonal and meridional prevailing winds.

Many investigators consider that zonal wind disturbances observed in winter characterized by direction reversals or sudden decrease of wind velocity are often connected with stratomesospheric warmings. In this connection it is of interest to compare time variations of zonal prevailing wind with the thermal regime of stratosphere. With this aim in view we used temperature data near the pole at the level of 10 hPa as well as radiance in the infrared referred to the levels of 4 pHa and 1,7 hPa (NAUJOKAT and LABITZKE, 1984, (Fig. lb).

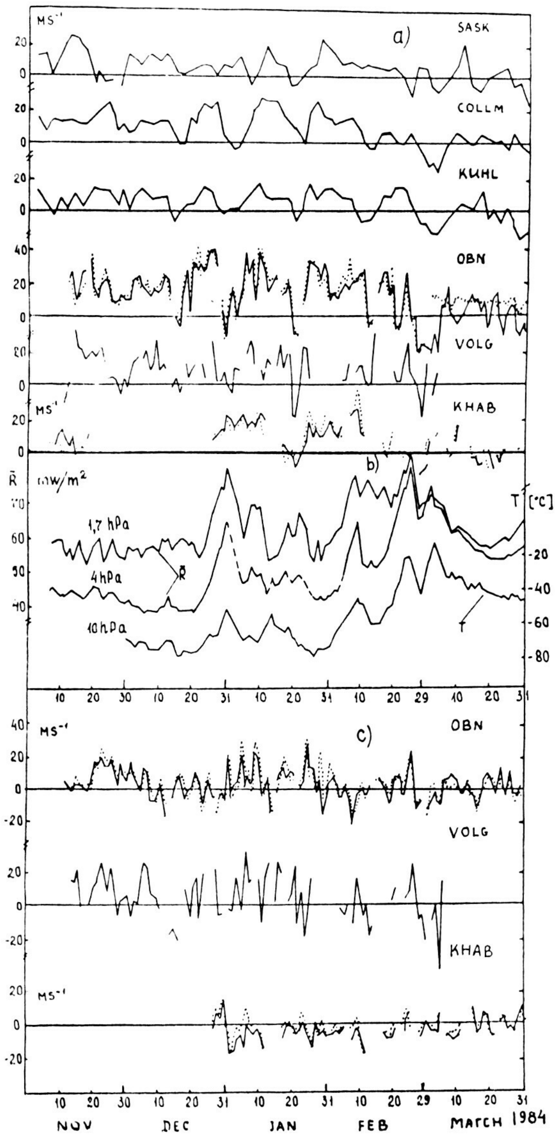

Fig. 1 Day-to-day variations of (a) zonal prevailing wind velocities (b) temperature near the pole at the level of 10 hPa and radiance in infra-red at 1,7 and 4 hPa and (c) meridional prevailing wind velocities.

According to the data from Obninsk (Fig. 1a), the first reversal of zonal wind occurred in the middle of December. At the same time easterly winds were observed in the lower thermosphere over Volgograd (Fig. 1a) and Collm. The decrease of westerly winds practically to zero was observed in Kuhlungsborn and Saskatoon. Due to the fact that all the observation sites are located in a narrow latitudinal interval one can conclude that in the middle of December there was a global disturbance of zonal circulation in the lower thermosphere with a slight dependence on longitude. The analysis of the vertical zonal wind profile from observation data from Saskatoon (NAUJOKAT and LABITZKE, 1984) shows that the boundary between easterly (above 105 km) and westerly (below 105 km) wind usually observed at 105 km in winter shifted to 97 km in the middle of December. At the same time, in the stratosphere at the level of 10 hPa at 60°N (NAUJOKAT and LABITZKE, 1984) there were no significant variations of the mean zonal westerly wind. Hence, the height gradient of the zonal wind in the mesosphere-lower thermosphere increased on the average. According to the thermal wind equation such an increase of the zonal wind gradient means that the latitudinal temperature gradient also increases. So, it can be stated that temperature has increased from middle latitudes to the pole (warming) and has decreased toward the equator.

Neither the temperature itself (Fig. 1b) nor the latitudinal temperature gradient (NAUJOKAT and LABITZKE, 1984) varied in the stratosphere during this period. This confirms the hypothesis that in winter in the mesosphere-lower thermosphere there may be warming (cooling) processes not connected with stratosphereic warmings.

The first significant stratospheric warming occurred late in December-early January. As seen from Fig. 1a, the reaction to this warming in the lower thermosphere was non-zonal. While in Obninsk, Kuhlungsborn and Collm there was a significant decrease of zonal wind velocity and even reversal of its direction, in Saskatoon and especially in Khabarovsk the stable westerly winds were maintained. It can be hypothesized that during this period the longitudinal structure of the zonal wind in the lower thermosphere was characterized by a planetary wave with the zonal wave number $s = 1$.

The reaction of lower thermospheric winds to the second warming wave in the stratosphere observed in the third decade of January (Fig. 1a) was different. During this period there occurred a reversal to easterly winds at all the sites (Obninsk, Volgograd, Kuhlungsborn, Collm an Saskatoon). Hence, the zonal wind reaction in the lower thermosphere can be classified as global and non-longitude dependent. According to data from Saskatoon (NAUJOKAT and LABITZKE, 1984) the lower boundary of the easterly wind zone decreased to 90 km. It can be said that during this period the thermal structure of the lower thermosphere qualitatively varied in the same way as during the disturbance observed in mid-November.

Lastly, the final stratospheric warming late in February-early March was accompanied by a zonal wind reversal at practically all the sites (Fig. 1a) and this disturbance was similar to the previous one in character. However, the zonal wind gradient with height in the

mesosphere-lower thermosphere changed its sign (NAUJOKAT and LABITZKE, 1984), i.e., the latitudinal temperature gradient also changed its sign. Hence, unlike the previously considered disturbances, in this case temperature should decrease from moderate latitudes to the pole and increase toward the equator. Such height structure of the zonal wind and latitudinal temperature structure are typical of the spring circulation reconstruction which begins usually late in March.

The analysis of day-to-day meridional wind variability observed in the lower thermosphere over Obninsk, Volgograd and Khabarovsk (Fig. 1c) showed that there is no clear-cut correlation between variations of the meridional wind and the temperature in the stratosphere. The meridional wind behavior over Obninsk and Volgograd significantly differs from that over Khabarovsk. At the same time there is a definite correlation between long-period (about two weeks) variations of meridional wind over Obninsk and Volgograd. There is no connection between velocity pulsations with periods of 2-5 days either for meridional or zonal wind components over all the observation sites. It should be noted that meridional wind velocities averaged over the observation period in Obninsk and Volgograd differ from the corresponding averaged values for Khabarovsk in absolute value as well as in sign. Thus, significant longitudinal dependence of meridional wind can be observed in winter and should be taken into account when constructing non-zonal models of global circulation.

These results as presented, show that the winter period is characterized by three types of disturbance in the lower thermosheric circulation regime: a) non-longitude dependent disturbances with the wind gradient varying significantly with height; b) longitude-dependent disturbances; and c) non-longitude dependent disturbances with the wind gradient significantly varying with height.

References

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